REMARKS

The Examiner is thanked for the interview courteously granted to the undersigned, in connection with the above-identified application. During this interview, clarification was obtained by the undersigned in connection with the rejections in the above-identified application. In particular, it was noted that a basis for rejection of claims 10 and 24 was not set forth in the outstanding Office Action mailed February 4, 2003, and that a Request for complete Office Action had been filed February 25, 2003. The Examiner indicated that she would consider this Request. Moreover the rejections based on U.S. Patent No. 5,770,095 to Sasaki, et al. were discussed. Differences between the teachings of this patent, as well as the other applied references, on the one hand, and the present invention, on the other, were discussed, and advantages achieved by the present invention due to these differences were also discussed. No agreement was reached during the interview.

Applicants have amended their specification to correct a typographical error at page 13, line 3, consistent with the required correction of the specification as set forth in Item 6 on page 4 of the Office Action mailed May 7, 2003.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended claim 1 to recite that the second protective-film forming agent has properties different from those of the first protective-film forming agent; and to recite that a combination of the first and second protective-film forming agents maintains a chemical mechanical polishing rate of the metal while controlling etching rate thereof. Note, for example, the paragraph bridging pages 8 and 9, as well as the

paragraph bridging pages 9 and 10, of Applicants' specification. See also the paragraph bridging pages 27 and 28, and the first two full paragraphs on page 28, of Applicants' specification

Claims 11-15 have been cancelled without prejudice or disclaimer; and claims 16, 17 and 19 have been amended such that these claims are dependent on only claim 1. Claims 23-33 have been cancelled without prejudice or disclaimer, in light of canceling of claims 11 and 15.

Moreover, Applicants are adding new claims 34-51 to the application. Claims 34-36, dependent respectively on claims 1, 34 and 34, respectively defines a chemical mechanical polishing rate and an etching rate, of the metal, achieved by the polishing solution; further defines the etching rate; and further defines the chemical mechanical polishing rate. Claim 37, dependent on claim 34, recites that the metal is selected from the group consisting of copper, a copper alloy, copper oxide and a copper alloy oxide. Claims 38 and 39 expressly set forth subject matter respectively expressly set forth in claims 2 and 3, but are dependent respectively on claims 5 and 6. Claims 40 and 41 further define the first and second protective-film forming agents, with respect to the function of the combination thereof in the polishing solution, of achieving a specified (reduced) etching rate while achieving an effective chemical mechanical polishing, consistent with the description on pages 27 and 28 of Applicants' specification.

New independent claim 42 defines a polishing solution for metal, including first and second protective-film forming agents, the first protective-film forming agent being a compound capable of forming a protective film by physically absorbing the first protective-film forming agent on the metal film surface and/or chemically linking

the first protective film-forming agent with the metal film surface, and a second protective-film forming agent which is a compound which assists the first protective-film forming agent in forming a protective film, the polishing solution having a chemical mechanical polishing rate of the metal of at least 100 nm/minute and an etching rate of the metal of at most 10 nm/minute. Claim 43, dependent on claim 42, recites that the solution consists essentially of the first and second protective-film forming agents. Claims 44 and 45, each dependent on claim 42, respectively further defines the etching rate and further defines the chemical mechanical polishing rate. Claims 46 and 47, each dependent on claim 42, each defines materials from which the first protective-film forming agent is selected; and claims 48 and 49, each dependent on claim 42, each defines a group of materials from which the second protective-film forming agent is selected. Claims 50 and 51, each dependent on claim 42, respectively recites that the metal contains at least one selected from the group consisting of copper, a copper alloy, a copper oxide and a copper alloy oxide; and recites that the solution substantially does not contain any abrasive grains.

In connection with amendments to previously considered claims, as well as in connection with the presently submitted claims, note, for example, the paragraph bridging pages 8 and 9, as well as the paragraph bridging pages 9 and 10, of Applicants' specification. Note also the various first and second protective-film forming agents disclosed on pages 14-22 of Applicants' specification. Note also pages 27 and 28 of Applicants' specification.

Applicants respectfully submit that all of the claims now presented for consideration by the Examiner patentably distinguish over the teachings of the

references applied by the Examiner in the Office Action mailed May 7, 2003, that is, the teachings of the U.S. Patents to Sasaki, et al., No. 5,770,095, to Chopra, et al., No. 6,206,756, to Berenz, et al., No. 4,537,654, to Kawakubo, et al., No. 5,691,219, and to Ronay, No. 5,876,490, and the article by Hayashi, et al., "A New Abrasive-Free, Chemical-Mechanical-Polishing Technique for Aluminum Metallization of ULSI Devices", in IEDM 92 (1992), pages 976-8, under the provisions of 35 USC §102 and 35 USC §103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a polishing solution for metal, or such a method of polishing metal, as in the present claims, including, inter alia, the first and second protective-film forming agents, and wherein the second protective-film forming agent has different properties from those of the first protective-film forming agent, and a combination of the first and second protective-film forming agents controls the etching rate, while maintaining chemical mechanical polishing rate, of the metal. See claim 1.

More specifically, the teachings of the applied references would have neither disclosed nor would have suggested such polishing solution for metal, having the first protective-film forming agent which is an agent which, in a comparison polishing solution together with the oxidizing agent, the oxidized –metal dissolving agent and water, and without the second protective-film forming agent, etches the metal at an etching rate of at most 10 nm/minute, and forms a sufficiently strong protective film on the metal so as substantially not to be removed therefrom (by a polishing pad); and having the second protective-film forming agent which is an agent such that the combination of first and second agents, in the polishing solution, controls the etching

rate to an etching rate of at most 10 nm/minute while permitting the chemical mechanical polishing of the metal to be performed (using a polishing pad). See claim 40; note also claim 41.

In addition, it is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would have suggested such polishing solution, or such polishing method, as in the present claims, wherein the solution includes the first and second protective-film forming agents, respectively being a compound capable of forming a protective film by physically adsorbing the first protective-film forming agent on the metal film surface and/or chemically linking the first protective-film forming agent with the metal film surface, and being a compound which assists the first protective-film forming agent in forming a protective film, with the solution having chemical mechanical polishing rate and etching rate, of the metal, respectively of at least 100 nm/minute and at most 10 nm/minute. See claim 42.

Furthermore, it is respectfully submitted that the teachings of these references as applied by the Examiner would have neither taught nor would have suggested the other features as recited in the present claims, including features as in claims 1 and 42, and, moreover, including (but not limited to) wherein the first protective-film forming agent and second protective-film forming agent are agents as set forth in claims 2-6, 38, 39 and 46-49, particularly wherein the first and second protective-film forming agents are those set forth in claims 38 and 39; and/or the chemical mechanical polishing rate, and etching rate, are those as set forth in claims 34-36, 42, 44 and 45; and/or wherein the second protective-film forming agent is a compound which assists the first protective-film forming agent in forming a protective film, in a polishing solution as set forth in claim 1 (see claim 7); and/or wherein the

polishing solution is adapted to be used to polish a metal containing at least any one of copper, a copper alloy, a copper oxide and a copper alloy oxide (see claim 16; note also claims 37and 50); and/or wherein the solution substantially does not contain any abrasive grains (note claims 17 and 51); and/or wherein the polishing solution consists essentially of the first and second protective-film forming agents (see claim 43).

Even assuming, arguendo, that the applied prior art would have established a prima facie case of obviousness, it is respectfully submitted that the enclosed Declaration establishes that the presently claimed subject matter is different, and provides unexpectedly better results over, the closest applied prior art (that is, the teachings of U.S. No. 5,770,095 to Sasaki, et al., containing, inter alia, glycine and/or an amidosulfuric acid), clearly rebutting any possible prima facie case of obviousness and further establishing unobviousness of the presently claimed subject matter.

In connection with this Declaration, it is noted that an unsigned Declaration Under 37 CFR § 1.132 is being submitted herewith. An executed Declaration, executed by Mr. Y. Kamigata, one of the named inventors of the above-identified application, will be submitted when received in the offices of the undersigned.

The invention as claimed in the above-identified application is directed to a polishing solution for polishing a metal, and a method of polishing using such solution, particularly suitable for polishing in forming wirings of semiconductor devices.

In recent years, chemical mechanical polishing has been performed in manufacturing semiconductor integrated circuits, particularly in the planarizing of

interlayer insulating films and in the formation of metal plugs and formation of buried wirings (for example, in the step of forming multi-layer wiring). In a common method for chemical mechanical polishing, a polishing pad is stuck onto a circular polishing surface plate; the surface of the polishing pad is soaked with a polishing slurry (containing abrasives) for metal; the surface of the substrate on which a metal film has been formed is pressed against the pad surface; and a polishing platen is rotated in a state in which a preset pressure is applied, so that hills of the metal film are removed by mechanical friction between the polishing slurry and the hills of the metal film. The abrasive in the slurry is a solid abrasive particle or powder.

However, when a conventional polishing slurry containing solid abrasive grains is used, there are problems in which the middle portion of the surface of a buried metal wiring is isotropically corroded to become hollow like a dish (dishing), polishing scratches due to the solid abrasive grains may occur, and a complicated cleaning process is required for removing any solid abrasive grains remaining on the substrate surface after polishing; and the initial cost of the solid abrasive grains themselves and the disposal of waste liquid bring about a high cost. Note the paragraph bridging pages 4 and 5 of Applicants' specification.

In order to avoid the problem of dishing, which is, for example, due to excessive etching (an excessive etching rate) of the metal surface being polished (compare the undesirable etching to the desired polishing), a method making use of a polishing solution which contains an oxidized-metal dissolving agent comprised of aminoacetic acid or amidosulfuric acid and benzotriazole has been proposed. However, the benzotriazole has so high a protective-film forming effect that it may

cause a great decrease not only in etching rate of the metal, but also a polishing rate thereof.

Accordingly, it is still desired to provide a polishing solution which avoids the need for solid abrasive particles and which avoids problems of, e.g., dishing and erosion (for example, erosion being silicon oxide loss from the surface being polished).

Against this background, Applicants have found that the foregoing problems are avoided through a polishing solution as in the present invention, having, inter alia, the first and second protective-film forming agents, in addition to the oxidizing agent, the oxidized-metal dissolving agent and water. That is, by use of the combination both the first protective-film forming agent and second protective-film forming agent as in the present claims, having properties different from each other, with the combination of the first and second protective-film forming agents performing functions as recited in claim 1, undesired etching (etching rate) can be controlled (e.g., reduce), while maintaining a desired high rate of polishing. See the paragraph bridging pages 8 and 9 of Applicants' specification. Applicants have discovered that by use of the first protective-film forming agent in combination with the second protective-film forming agent, the etching rate can be sufficiently low while the chemical mechanical polishing rate does not substantially decrease, even when the first protective-film forming agent is added in a low concentration. Through use of the polishing solution containing both the first and second protective-film forming agents, desired polishing rates can be achieved, without undesired etching, and without the need for solid abrasives.

In addition, as another aspect of the present invention, Applicants have found that a desired polishing (smoothing) effect can be obtained as long as the etching rate is controlled to 10 nm/minute or lower; and that when the etching rate is controlled to 1 nm/minute or lower, dishing does not substantially occur even when the chemical mechanical polishing is fully carried out. See the sole full paragraph on page 10 of Applicants' specification. Thus, Applicants have found a maximum allowable etching rate, and have found a desired polishing solution which etches at a level of at most this maximum allowable etching rate, while avoiding a reduction in chemical mechanical polishing, so that the desired polishing can take place without, e.g., dishing of the polished structure.

Moreover, Applicants have found specific materials for each of the first protective-film forming agent and second protective-film forming agent, which materials in combination achieve a desired polishing rate, while avoiding an unduly large etching rate.

It is to be emphasized that the present invention has come about by, e.g., the discovery by Applicants of use of two protective-film forming agents in combination, with the second protective-film forming agent assisting the first protective-film forming agent in forming the protective film, and with the agents in combination maintaining the chemical mechanical polishing rate while reducing the etching rate. Such discovery of use of the combination of the first and second protective-film forming agents as recited in the present claims, and advantages thereof, would have been neither disclosed nor would have been suggested by the teachings of the applied references, as discussed infra.

Sasaki, et al. discloses a polishing agent and polishing method, for use in a micro-processing step. The polishing agent includes a chemical agent responsible for forming a protection film on the surface of the substrate to be polished by reacting with the material containing a metal as a main component. See column 2, lines 7-15. Sasaki, et al. discloses that it is preferred that the polishing agent contain an aminoacetic acid and/or an amidosulfuric acid, an oxidizing agent, water and benzotriazole. This patent discloses that when benzotriazole is not added, a polishing rate as high as approximately 250 nm/minute and an etching rate as high as approximately 45 nm/minute occurs; and as the amount of benzotriazole increases, both polishing rate and etching rate decrease exponentially.

It is respectfully submitted that Sasaki, et al. would have neither disclosed nor would have suggested the polishing solution, or the method of polishing, as in the present claims, including wherein the solution includes the combination of both the first and second protective-film forming agents, the second protective-film forming agent having properties different from the first, and with the combination of the first and second agents functioning as recited in claim 1, and, in particular, as in claims 40 and 41.

The contention by the Examiner in Item 8 on pages 4 and 5 of the Office Action mailed May 7, 2003, that Sasaki, et al. discloses an aminoacetic acid (such as glycine) and/or an amidosulfuric acid which is the same as Applicants' oxidized-metal dissolving agent and second protective-film forming agent is respectfully traversed. Contrary to the contention by the Examiner, it is respectfully submitted that the aminoacetic acid and/or amidosulfuric acid, either alone or in combination, and even in light of the remaining teachings of Sasaki, et al., would have neither

taught nor would have suggested, inter alia, the second protective-film forming agent, much less the combination of first and second protective-film forming agent as in the present claims.

In addition, attention is respectfully directed to the enclosed copy of the Declaration of Y. Kamigata, one of the named inventors in the above-identified application. It is respectfully submitted that this Declaration uses various examples of combinations of amidosulfuric acid and/or glycine (an aminoacetic acid), and together with results within the scope of the present invention, shows that the solutions (1) - (4), containing glycine and/or amidosulfuric acid, do not achieve the unexpectedly better results achieved according to the present invention (note Items 14-16 on pages 5 and 6 of the enclosed Declaration).

It is respectfully submitted that the statement by Mr. Kamigata in Item 5 on page 2 of the enclosed Declaration, that glycine and/or amidosulfuric acid do not qualify as a second protective-film forming agent as in the present invention, especially together with the unexpectedly better results shown for compositions of the present invention, establishes a difference between the present invention and the teachings of Sasaki, et al., and unexpectedly better results achieved due to these differences, so as to establish unobviousness with respect to the closest prior art.

The Examiner's attention is respectfully directed to the various second protective-film forming agents disclosed, for example, on pages 17-21 of Applicants' specification. Clearly, this further establishes that the aminoacetic acid (such as glycine) and/or amidosulfuric acid as in Sasaki, et al. does not fall within the second protective-film forming agent of the present claims; and, moreover, it is respectfully

submitted that the compositions as in Sasaki, et al., including glycine and/or an amidosulfuric acid, would have neither taught nor would have suggested polishing solutions or methods of use thereof as in the present claims, including the second protective-film forming agent, particularly in combination with the first protective-film forming agent, and advantages thereof.

In addition, it is noted that Sasaki, et al. discloses a polishing rate as high as approximately 350 nm/minute and the etching rate as high as approximately 45 nm/minute. Note column 7, lines 24-30. This patent discloses further that as the amount of benzotriazole increases, both the polishing rate and etching rate decrease exponentially. It is respectfully submitted that this reference would have taught away from a polishing solution as in the present claims, having the polishing rate of at least 100 nm/minute and etching rate of at most 10 nm/minute, and advantages thereof, as discussed in the present application and described in the foregoing.

It is respectfully submitted that the secondary references as applied by the Examiner would not have rectified the deficiencies of Sasaki, et al., such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Kawakubo, et al. discloses a technique of manufacturing a semiconductor memory device. The method includes forming a switching transistor on a semiconductor substrate; forming an insulating layer on the substrate; forming a trench in the insulating layer; forming a conductive layer in the trench and on the insulating layer; and polishing and removing those portions of the conductive layer which are provided on the insulating layer, thereby forming a bottom electrode for a charge storage element. Examples of materials for this bottom electrode are a

noble metal such as platinum, gold, palladium, rhodium, iridium, ruthenium, rhenium or the like, an alloy of any one of these metals or an oxide of any one of these metals. This patent discloses in column 5, lines 26-33, that if chemical mechanical polishing is employed for the polishing of the conductive layer, it is desirable to use a polishing solution which contains a halogen, a halogen salt and an organic solvent; and that the polishing solution dissolves the noble metal contained in the conductive layer, without dissolving the oxide film or barrier metal film which is provided beneath the conductive layer.

Initially, it is emphasized that Kawakubo, et al. discloses removal of noble metal. This patent discloses that the polishing solution contains a component which dissolves the noble metal. It is respectfully submitted that the teachings of this reference, even in combination with the teachings of Sasaki, et al., would have neither taught nor would have suggested the presently claimed solution or method of use thereof, having the recited components including the oxidizing agent, and including use of the first and second protective-film forming agents, or polishing/etching rates, or other aspects of the present invention as discussed in the foregoing.

The Examiner contends that Kawakubo, et al. teaches a polishing solution which contains an organic solvent such as alcohol and ester in which it shortens the time of polishing. Applicants respectfully request that the Examiner point out the specific basis for her contention that the "organic solvent" has an effect on the time of polishing; in this regard, note that the organic solvent is disclosed as being one that does not react with halogens. In any event, even as applied by the Examiner Kawakubo, et al. discloses a polishing solution having an effect on the time of

polishing; it is respectfully submitted that the teachings of this reference, even in combination with the teachings of Sasaki, et al., would have neither taught nor would have suggested the combination of the first and second protective-film forming agents, having properties as discussed in the present claims, and advantages thereof. In this regard, it is again emphasized that the "alcohol, ester" in Kawakubo, et al. is described as a solvent contained in the polishing solution.

Ronay discloses a slurry composition useful for polishing and especially for planarizing surfaces in the micro-electronics industry; the slurry contains abrasive particles, and as a portion of these particles are used particles that exhibit reduced or diminished polishing action and normal stress effect, with a fraction of the abrasive particles having a polyelectrolyte adsorbed on the abrasive particle. Note column 2, lines 15-28.

Even assuming, arguendo, that the teachings of Ronay were properly combinable with the teachings of Sasaki, et al. and Kawakubo, et al., such combined teachings would have neither disclosed nor would have suggested the presently claimed subject matter, including the combination of the first and second protective-film forming agents, having the recited characteristics, or the solution having the recited polishing/etching rates, and advantages thereof.

The Examiner has referred to Ronay as describing use of the second protective-film forming agent, the Examiner referring to the paragraph bridging columns 6 and 7 of Ronay. It is respectfully submitted that the portion of Ronay as applied by the Examiner refers to tungsten planarization, not planarization of copper or materials containing copper as in various of the present claims; and in particular refers to a polyelectrolyte such as poly (acrylic acid) adsorbed on abrasive surfaces

to prevent scratching. Clearly, this disclosure of Ronay would have taught away from those aspects of the present invention wherein the solution contains substantially no abrasive. Moreover, noting that the polyelectrolyte is adsorbed on the abrasives, it is respectfully submitted that this reference, alone or in combination with the teachings of the other applied references, would have neither disclosed nor would have suggested, and in fact would have taught away from, the presently claimed subject matter, including function of the first and second protective-film forming agents in combination, in the polishing solution, and advantages thereof, and other aspects of the present invention as discussed in the foregoing.

The contention by the Examiner on page 6 of the Office Action mailed May 7, 2003, that Ronay discloses using the second protective-film forming agent, is respectfully traversed. Ronay discloses use of a polyelectrolyte employed to be adsorbed on the abrasive particles, and not a second protective-film forming agent, much less the combination of first and second agents, and function thereof, and advantages achieved thereby, as in the present invention.

Chopra, et al. discloses tungsten chemical mechanical polishing processes using fixed abrasive polishing pads. This patent discloses that the polishing solution used to polish the tungsten layer includes a tungsten oxidizing component present at from about 0.5% to 15% by volume and a pH of less than or equal to about 6.0, the tungsten-comprising layer being chemically mechanically polished with a fixed abrasive pad with the solution being received between the wafer and the pad. Note the paragraph bridging columns 1 and 2 of this patent.

It is respectfully submitted that the teachings of this reference, either alone or in combination with the teachings of Sasaki, et al. would have neither taught nor

would have suggested the presently claimed subject matter, including use of both the first and second protective-film forming agents, especially in combination, or the polishing/etching rates, or other aspects of the present invention as discussed in the foregoing, and advantages thereof.

The Examiner notes that Chopra, et al. discloses a polishing solution containing ammonium citrate. However, the ammonium citrate in Chopra, et al. is a buffering agent; and it is respectfully submitted that the disclosure therein, alone or in combination with the teachings of the other applied references, would have neither taught nor would have suggested the solution of claim 10, including ammonium citrate as the oxidized metal dissolving agent.

In connection with the rejection set forth in Item 12 on page 7 of the Office Action mailed May 7, 2003, Hayashi, et al. discloses a polishing technique for aluminum metallization, in which aqueous amine and hydrogen peroxide solution are used as a polishing liquid. This publication discloses that scratch-free aluminum plugs embedded in silicon oxide films are obtained by polishing using this solution, with a high polishing selectivity of the aluminum to silicon oxide.

Even assuming, arguendo, that the teachings of Hayashi were properly combinable with the teachings of Sasaki, et al., Kawakubo, et al, and Ronay, such combined teachings would have neither disclosed nor would have suggested the polishing solution and/or method as in the present claims, particularly for polishing copper (note that Hayashi, et al. is directed to polishing aluminum), and including the combination of the first and second protective-film forming agents as in the present claims, and/or the polishing/etching rates, and advantages achieved by the present invention.

Berenz, et al. discloses a fabrication technique for field-effect transistors, particularly, for etching of multiple via holes in a substrate wafer. The method is described most generally at column 1, lines 49-59; and, more specifically, in column 1, line 60 to column 2, line 49.

Even assuming, arguendo, that the teachings of Berenz, et al. were properly combinable with the teachings of Sasaki, et al., it is respectfully submitted that the combined teachings of these references would have neither disclosed nor would have suggested the presently claimed invention, including use of the combination of the first and second protective-film forming agents, and advantages thereof; and/or the etching/polishing rates, and advantages thereof, as discussed previously.

In connection with the rejections set forth in Items 14-17 on pages 9-11 of the Office Action mailed May 7, 2003, note that the claims referred to in these items have been cancelled without prejudice or disclaimer. In any event, it is respectfully submitted that the combined teachings of these references would have neither disclosed nor would have suggested the aspects of the present invention as discussed previously including, but not limited to, the use of the combination of the first and second protective-film forming agents, and/or the polishing/etching rates, as discussed previously.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims remaining in the application are respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR § 1.136. Please charge any shortage in fees due in connection with the filing of

this paper, including extension of time fees, to the Deposit Account No. 01-2135 (Case No. 566.39787X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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